

ON SYSTEMS THINKING and WAYS of BUILDING it in LEARNING

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ABSTRACT

The article focuses on the issue of shaping learners' systems thinking skills in the context of traditional education using specially elaborated system methods that are implemented based on the standard textbook. Applying these methods naturally complements the existing learning process and contributes to an efficient development of learners' intellectual capabilities and the necessary skills for a holistic discovery of the world. The learning process provides training in a number of specific skills for having a comprehensive approach to organizing and implementing cognitive, theoretical and practical activity, while providing opportunities for learners to acquire and apply various forms of activity and actions which contribute to improve the efficiency and quality of learning, the learner's competitive ability as well as to intensify the learning process. Along with achieving the main learning goal and providing learners with new knowledge, skills and practices, the proposed techniques and methods include the implementation of the acquired knowledge in research and art.

KEYWORDS

learning process; comprehensive approach; systems as a means of achieving a goal.

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Introduction

One of the objectives of the present article is to highlight the importance of shaping comprehensive and global thinking habits among young people and professionals, which are necessary, today, for the good functioning of society, state and humanity in general. As an example, Kazakhstan has never set such a goal. Besides, the national system of education lacks learning programs and methods that are required to achieve it.

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Many years of research have shown us that a comprehensive approach to organizing and implementing the learning process helps to considerably improve the efficiency and quality of learning and contributes to build and develop the learners' knowledge and skills for having a comprehensive approach and systems thinking in their cognitive activity, among other things.

The implementation of the comprehensive approach includes not only the elaboration of some proper learning methods, but also their application by the learners. A systematic use of these methods in the learning process and independent work contributes to the shaping of some specific system representations. One special feature of this approach is that it is in line with traditional education and constitutes its developing component. The very process of shaping systems thinking has a considerable impact on the learners' intellectual capabilities. Besides, experiments have shown that this process contributes to build consistency of generated knowledge and of the corresponding subject matter thinking.

A targeted shaping of systems thinking and perceptions among the learners along with their acquiring and implementing relevant methods and activities is one of the key factors of the learning process intensification.

The use of standard textbooks and learning materials increases the efficiency of shaping systems thinking and approach knowledge and skills. At the same time, these learning materials are interpreted as a holistic information system, and we suggest that the already mentioned comprehensive methods should be used when dealing with it.

The notion of systems thinking used in our research

Academic literature gives a variety of definitions of what systems thinking is, offering a general idea of the concept and essence of this phenomenon.

In our view (Sarybekov, et. al. 2008), systems thinking means that people are able to establish links between different branches of science, to grasp universal scientific laws that lie at the foundation of their development and to have some general understanding of how nature and society evolve.

Ian McDermott and Joseph O'Connor define systems thinking as approach helping us to see and understand the meaning and inner logic of the observed sequences, or patterns, of events so that we may prepare ourselves for the future and influence it, to a certain degree, which means we will be able, in a sense, to keep the situation under control (O'Connor and McDermott 2008).

Pushkar and Potrashkova understand systems thinking as a capacity to have an integrated view of a phenomenon in the thinking process; the reflection – in human conscience - of real-life objects and phenomena in their multiple aspects, integrity and interrelationship (that is, as systems and their parts); an individual's ability to perceive a specific phenomenon from a bigger number of perspectives (viewpoints) than an ordinary person; a person's ability to see himself as part of large-scale processes and events. This means that, no matter where a person works and no matter what he does, he always is a component of some system (academic, economic, social, etc), and the efficiency of his activity and

decisions depends largely on how well he or she understands this system's structure and inner logic (Pushkar & Potrashkova 2008).

Donella Meadows interprets systems thinking as a new means of describing and discovering the surrounding world, and this means takes into account that "everything is related to everything", that interrelations may be of non-linear nature and thus form cycles of back relations and that the system is, overall, more than a mere combination of its parts (Meadows 2010).

When describing a systems thinking style as an objective integrative tendency of scientific knowledge, I. B. Novik distinguishes three major foundations (Novik 1986): 1) multilateralism; 2) the evolution process's consistency; 3) caution against absolutizing its independent parts and strokes of knowledge.

V. A. Ganzen identifies systems thinking as a specific thinking style that is opposite to, or confronting, local, inconsistent and one-sided thinking. According to Ganzen, a person having systems thinking sees any entity as a whole divided in parts and consisting of parts and strives to discover order of these parts in a whole. Since it is possible to view almost anything from this perspective, a person having systems thinking obtains universal opportunities (tools) to penetrate into any branch of knowledge and activity (Ganzen 1992).

In Y. V. Ksenchyuk's view, systems thinking is "when we 'go beyond' an organization and analyze it not from the position of a participant in this inner process, but from that of the outer environment. It is when we try to grasp our system's dynamic complexity and see the forest for detached trees" (Ksenchyuk 2011).

Linda B. Sweeney and Donella Meadows assert that systems thinking and organizational learning bear within them interconnected concepts, ranging from systems dynamics (the study of causal relationships and delays in complex systems) to mental models (all our inner ideas about the world structure, our assumptions, legends and faith).

Being a systems thinker, man sees the big picture at all times, analyses complex systems from different point of view so as to grasp new key points; speculates on how mental stereotypes influence our future; gives preference to long-term prospects; sees far and wide (is a broad-minded person); is able to establish intricate causal relationships, to foresee where unwanted consequences may emerge, to dig to the roots and focus on facts instead of reproaches and accusations; is able to accept the existent of paradoxes, contradictions and discords without trying to settle them at any cost (The Systems Thinking Playbook: Exercises to Stretch and Build Learning and Systems Thinking Capabilities).

Sweeney's and Meadows's experience in shaping systems thinking is interesting: they build it on the basis of games and exercises, according to which learning is delivered mostly in team. With this goal in mind, it is suggested to conduct special trainings using five "disciplines:" professional training in team, personal skills, shared vision, mental models and systems thinking. In their view, systems thinking and organizational learning bear within them interconnected concepts, ranging from systems dynamics (the study of causal relationships and delays in complex systems) to mental models (all our inner ideas about the world structure, our assumptions, legends and faith) (The Systems Thinking Playbook: Exercises to Stretch and Build Learning and Systems Thinking Capabilities).



In our opinion, L. I. Shragina reveals a more general significance of systems thinking, as she claims that it provides the opportunity to implement a systems approach in various practical areas (Shragina 2010).

Our own research has shown that the implementation of the systems approach to the learning process is one of the major conditions to build systems thinking in learning.

The authors of the study (Reshetova 2002) state that the systems approach modifies the way of defining the subject, the research program, knowledge frameworks, their interrelation guidelines, the logics of cognitive movement within the subject, the way of building a theoretical picture. In this respect, systems thinking makes it possible to find one's way in the ever-increasing knowledge flows, gives an opportunity to select knowledge to one's liking and to integrate them with a view to build a tentative basis for dealing with various issues emerging from a new research subject and with finding a way to tackle them.

A common methodological position of systems thinking is to interpret the entities of any science from one and the same viewpoint in one of their universal forms of being: in the form of systems perceived as a whole in union with their parts' inner complexity and organized nature.

"If a learner has a well-shaped tentative representation of a subject's systems foundations, he will find it easy to make sense of new knowledge; he can catalogue them by subject, by this subject's level structures; he is also able to determine the appearance of new features in these structures' elements and relationships, to pick necessary information out of the totality of knowledge with a view to construct the subject and solve respective tasks, and to accentuate the "trunk" part of the studied subject at different levels of learning" (Reshetova 2002).

Z. A. Reshetova asserts that learning to think systematically is a socially recognized need. The current learning practices are not, however, aimed to build this skill among the learners. Shaping the learners' theoretical thinking skills in modern scholarly generalizations, which are expressed by the systems approach principles, is a major issue in the learning process. The systems approach is interpreted as a methodological basis for introducing the subject matter of an academic discipline and for organizing the acquisition process in the form of a theoretical activity aimed at researching the subject as a system. The very process of such an activity forms the systematic methods and technologies, which act for the learners as a cognitive tool, whose acquisition becomes a cognitive way of making sense of a subject (Reshetova 1985).

The systematic way of organizing and implementing cognitive, theoretical and practical activity, based on the systems approach, in the process of interiorizing activity becomes one of the ways of systems thinking.

We define systems thinking as an indirect and generalized reflection of real life, which is based on the consistency principle and is related to the implementation of the systems approach in human cognitive, theoretical and practical activity.

Methods and techniques for shaping systems thinking in learning

The combination of analysis, to which considerable time is usually accorded, and synthesis, which is not duly implemented in the learning process, are rather important mental processes of systems thinking. Modern training must contain

mechanisms that would facilitate the development of synthetic thinking. When a teacher or a professor makes efforts to teach the learner to summarize and synthesize what they have learnt, he or she does so on his or her own initiative, without relying on tried and tested methods.

According to the authors of the work, entitled "The Art of Systems Thinking: Essential Skills for Creativity and Problem Solving", analysis provides us with knowledge, while synthesis helps us understand (O'Connor and McDermott 2008). It is impossible to acquire knowledge and skills for an integrated discovery of the world surrounding us without mastering the techniques and methods of summarizing and synthesizing the information under examination.

One of the fundamental ideas of the present study is to show the importance of implementing into the education system the systems approach as a research, construction and implementation methodology of all education system components as systems and, above all, of the integrated activity organization of the learners.

In our experiments, the process of forming systems thinking skills, among others, has been carried out within the context of a conventional lesson using a standard textbook. Figure 1 shows the overview of a working combination of traditional and innovative training, which ensures not only a remarkable achievement of the aims and objectives of a lesson, but also the development of systems thinking skills and of the systems approach to the learners' cognitive and other activities. What is meant here is the introduction of an unconventional, supplementary kind of training, aimed at implementing the systems approach, at considerably improving the efficiency and quality of the learning process itself, and, finally, at emphasizing the learners' independent and creative involvement in the learning process.

The following were among the prerequisites for conducting the experiments: the learners' motivation; their understanding of some basic notions, concepts and other features of the systems approach; self-management skills development in cognitive and other activity.

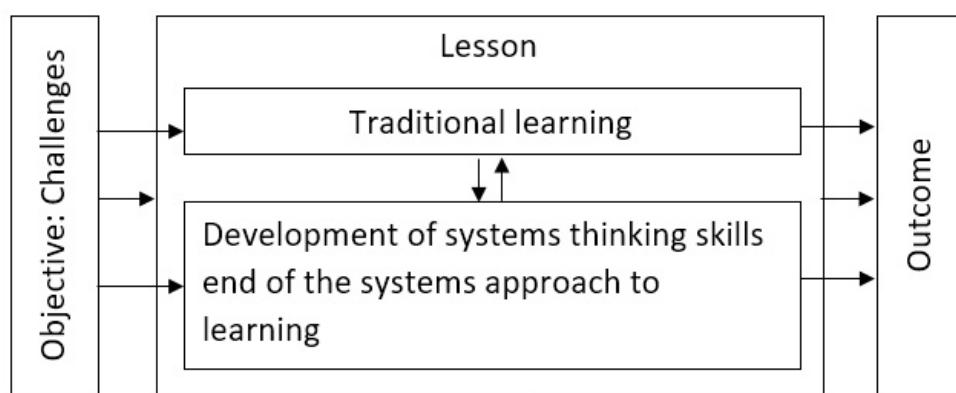


Figure 1. Overview of the combination of traditional and "innovative" learning

The study of the learning material based on the systems approach has been carried out using specially developed methods and techniques, including:

1. An accelerated analysis of the textbook and its components as systems with a view to conduct an in-depth study of them and, subsequently, synthesize,



specify, generalize, systematize, create a conceptual system model of the studied information, make conclusions, reflect on them, etc.

It has been suggested that, for a quicker immersion into the studied material, the learners should make use of the textbook's table of context, which were later used to create a conceptual model of the studied material's system.

2. A consistent, thorough and extended analysis of the original learning material (i.e. presented in a textbook) as a system, synthesis, specification, synthesis and systematization of the revealed information, construction of the conceptual model of the information system under study, interpretation of the obtained model, conclusions, reflection on them.

The above-mentioned work with the studied information has been supplemented with practical work on using the acquired knowledge at the "standard" level, at that of creativity and at that of research. Besides, the learners carried out, with a view to develop their self-management skills, self-organization of learning, self-control and self-assessment of the acquired knowledge and skills using special three-level evaluation cards. Advanced, intermediate and low levels have been established as criteria.

3. System structurization, study and "twisted" presentation of information about the investigated entity. In line with the given method, the manifold study of the investigated entity and of its components has been carried out using the following kinds of activity and actions:

- analyzing the entity and its components;
- modelling and monitoring (original and modified) conditions for the entity's existence, functioning and evolution;
- studying and monitoring (exterior and inner) factors, which are capable of modifying the status of the entity and of its components, along with consequences of these factors' impact;
- monitoring the condition of the entity and of its components;
- practical work on meeting the challenged, implementing the acquired knowledge at "standard" (knowledge and skills meeting the education standards), creativity and research levels;
- identifying and studying problems and challenges, problem-solving;
- scientific research on various issues related to the studied entity and its components, research methods, results managements, etc.;
- predicting the future condition of the entity and of its components;
- investigating and taking into consideration other experiences, acquiring our own experience (including the use of the systems approach in cognitive and other activity);
- improving the entity and its components, methods of studying it, etc.
- other.

A key element in implementing the method of system structurization, the manifold study "twisted" presentation of information about the investigated subject was the learners' acquisition of the above-mentioned types of activity and actions along with corresponding thinking patterns.

4. Identifying and studying the hierarchy and the hierarchical relationships of the investigated entity's system. Non only vertical relationships (paragraph-chapter-unit-textbook-science/branch of science, to which the given textbook belongs) have been established and monitored during the learning process, but also the horizontal ones (for example, relationships between paragraphs in the context of the studied chapter, etc.).

5. Studying the evolution dynamics of the studied entity and of its components as systems, and the conditions of the super-system, to which the studied entity's system belongs. The entity under investigation, its super- and sub-systems are being studied, taking into consideration their past, present and future conditions. It is suggested that the methods proposed by us and/or other methods should be used to analyze, systematize and generalize the obtained information.

Any entity can be studied as a whole, if investigated not only in its original condition, but also considering its functioning and behavior under different conditions and under the influence of factors that are capable of modifying its current condition. This kind of examination of the entities under consideration is extremely rare, especially, in high school.

6. Identifying, in learning materials, and studying entities that have connections with other systems and super-systems, no matter if these entities had been previously studied or not.

As an example, the second paragraph in Chapter X, entitled "Theory and Practice of Educational Work in a Professional Education Institution" ("Professional Pedagogy", a textbook edited by the education specialist at the Russian Academy of Education S. Y. Batysheva), is dedicated to the systems and synergetic education theory (Professional Pedagogics: A Textbook for University Students).

The learner must be familiar with certain principles of the systems and synergetic approaches in order to understand and use in real life this theory. In the above-mentioned paragraph, the learner will meet such notions as "synergetic condition", "synergetic contact", "synergism", "synergetic theory of educational interaction", "synergetic condition of mentality", etc., and he or she will need to go beyond professional pedagogy to understand them.

It is always a difficult challenge to provide such an information system with the required content, integrity and accessibility for the learners. All systems methods mentioned in the present study are, nonetheless, employed to explore such entities.

In most cases, the study of unknown entities is presented for informative purposes only, indicating major directions for further research. As practice shows, some authors use, when giving supplementary information, a great number of entities having connections to different super-systems and systems, which considerably reduces the efficiency of studying specific learning material.

7. A systematic study of specific situations occurring in learning materials as well as of situations that can be introduced on purpose to reveal some other (i.e. not shown in the studied material) features of the entity.

8. The implementation of the acquired systems thinking knowledge and skills and other ways of thinking, of the systems and other (analytical, factorial, practical, forward-looking, research, etc.) approaches to cognitive and other activity at the "standard" level (knowledge and skills meeting official education standards), at creativity and research levels.

9. Systems thinking knowledge and skills have been assessed according to three levels:

Low level—bad understanding of accomplished actions, unsure and conventional use of the systems approach and of the proposed methods, implementation of the acquired knowledge at the "standard" level, underdevelopment of common analysis, synthesis and modelling skills, lack of



communication skills and of drawing conclusions, poor reflexive thinking, low level of self-organization, of self-assessment, of self-control and of independence;

Intermediate level – awareness of accomplished actions, confident use of the systems approach and of the proposed methods, implementation of the acquired knowledge at “standard” and creativity levels, presence of the acquired systems representations and required analysis, synthesis and modelling skills, ability to draw conclusions, good reflexive thinking, good self-management skills;

Advanced level – high awareness of accomplished actions, confident and creative use of the systems approach and of the proposed methods, implementation of the acquired knowledge at “standard”, creativity and research levels, clear understanding of systems representations and required analysis, synthesis and modelling skills, speed and precision in drawing conclusions, excellent self-management skills.

10. Monitoring (and assessment) of the learning process and of the obtained results based on the systems approach has been carried out by implementing the proposed types of activity and actions along with systems methods and techniques.

The day before the experiments, all selected teachers and professors took part in special seminars and trainings working on graduate works and delivering mock demo lessons.

Every participant in the experimental groups was provided with necessary teaching aids describing in detail every method and illustrating it with examples of how to implement them in real-life teaching.

The proposed methods were gradually implemented into the learning process over a certain period of time, but only after all participants had mastered them, spending most of their time on getting familiar with the method on system structurization, study and “twisted” presentation of information about the investigated entity.

All those who participated in the experiments in an effort to master the proposed methods and types of activity and actions were controlled on an ongoing basis. Special self-study task cards containing self-management (self-organization, self-control, self-assessment) elements had been handed out to the participants for this purpose.

The use of three-level cards featuring questions, tasks and assignments of varying degrees of complexity and meeting relevant education standards along with cards containing questions, tasks and assignments aimed for creative and research levels, provided optimal conditions for individualization of the learning process and for control over the dynamics and outcomes of training.

The study of every paragraph has been followed by examinations and tests aiming to assess not only the efficiency and quality of training, but also the process of the learners’ mastery of the proposed types of activity and methods and their acquisition of systems thinking knowledge and skills.

The study of the entity under investigation (for example, learning material) using the systems approach methods was first carried out in a conventional, or “static” way (considering how the material is presented in the textbook), and then under the influence of exterior conditions and factors.

Main results

The long-standing implementation of the above-mentioned systems thinking development methods has shown this process's influence on the increase in the efficiency and quality of learning, acquisition of knowledge and skills.

We have conducted research in this area since 1985. The first attempts to implement our research results in education have been carried out in the Djambul Irrigation and Construction Institute (now Taraz State University named after M. Kh. Dulaty) in Kazakhstan (Intensification of the Learning Process and of the Students' Independent Work; Methodological Foundations of the Intensification of the Learning Process in Higher Education). Experiments were also performed in some secondary education institutions. Some research on shaping systems and analytical thinking were carried out in the Academy of Public Administration under the President of the Republic of Kazakhstan (2001-2007) (Kaykenova 2005; Methodological Aspects of the Innovative Training of Government Officials; Theoretical Foundations of the Innovative Training of Government Officials; Burakanova, et. al. 2008; A Systems Approach to Structuring the Educational Content for Government Officials; Urkumbayev 2011) and in the Academy of National Security of the Republic of Kazakhstan (2004-2009).

Today, research on processes relative to shaping thinking in education is going on in the Forward-Looking Training of Personnel Research Center of the Kazakh Agrotechnical University named after Saken Sefullin.

Our research has revealed that training based on the systems approach ensures thorough understanding (up to 98%) of the learning material while reducing time input, which is due to the intensification of the learning process and the use of specially elaborated systems methods, as described above.

Quick immersion into the textbook's chapters facilitated the shaping of the tentative basis for the subsequent synthesis and generalization as well as the construction of a conceptual model of the studied material. The given model of a comprehensive and "twisted" presentation of the totality of the studied information, which is to be acquired, remains in human memory for a long time and, when necessary, unfolds itself quickly. Our research on what knowledge remains in human memory one and three years after the completion of studies confirms this assumption.

An intensive study of some chapters from a Mathematics textbook followed by a review of the studied content and a configuration of the relevant (unfolded) conceptual system model of the revealed information. Hereafter, we have thoroughly examined the content in the context of the obtained conceptual model of the studied content. Experiments have shown a considerable increase in the efficiency and quality of learning along with a major reduction of time spent on acquiring basic knowledge. The remaining time was devoted to practical work and applying the acquired knowledge at "standard", creativity and research levels, resulting in a thorough acquisition of basic knowledge.

The analysis of each paragraph was complemented, in the process of studying a textbook chapter, by an individual and, then, collective assessment of whether its content corresponded to the paragraph and chapter (unit) titles. With time, our extensive experience in performing this kind of tasks allowed us to further develop the learners' critical thinking skills. The use of this technique in various methods for shaping systems thinking has made it possible for us to single out systems-critical thinking as an independent research subject.



The examination of the study content in the initial condition as well as in modified situations with consideration for various factors affecting the learning process has contributed to the development of functional thinking, which featured certain flexibility and efficiency, and of integrated/scientific discovery of the surrounding real world.

In modified situations with consideration for factors affecting the learning process, the acquired basic knowledge was actively implemented at creativity and research levels. The use of specially designed cards containing tasks, exercises and assignments at the "standard" level, which meets the requirements of a relevant educational standard, as well as at creativity and research levels has allowed us to demonstrate the learners' active development of creativity and of "subject matter" thinking, resulting from the study of a specific discipline).

The method of system structurization, study and "twisted" presentation of the revealed information about the examined entity, which we presented in the present study, has allowed us to structure and acquire both information and the activity that was being accomplished at that time.

On the whole, the presented systems methods have contributed to:

- Acquire systems thinking skills and approach to cognitive and other activity;
- Develop the learners' intellectual capabilities;
- Develop the learners' and specialists' creativity;
- Get a comprehensive understanding of real-life entities;
- Acquire the types of activity and actions and corresponding ways of thinking that we described in our methods;
- Reveal systems information about the studied entity, on the basis of which we constructed the system model of the studied entity;
- Build and develop relevant knowledge belonging to a specific "subject" area and necessary for efficient analytical work;
- Develop interdisciplinary connections and improve activities and methods aimed at shaping systems thinking skills and the systems approach in cognitive and other activity;
- Create situations helping to examine the studied content under the influence of exterior conditions and factors capable of modifying the condition of the given entity;
- Work out and make decision in terms of education, management, etc.
- Build and develop self-management skills in cognitive, theoretical and practical activity;
- Ensure the objectivity of the obtained information;
- Create certain conditions for practical, efficient and critical analysis of a given situation;
- Increase the efficiency and quality of analytical work.

The acquisition of experience of systems thinking and of the systems approach to cognitive and other activity has considerably contributed to the speed, efficiency and quality of analytical, synthetic, research and practical work with the information under discussion, its understanding, quick generalization, arrangement, concretization and its unfolding and folding to the system's conceptual model depending on the set objective.

As mentioned above, the process of intensive formation of systems thinking skills has a major influence on the development of the learners' intellectual capabilities and "subject matter" thinking (Karimova, et. al. 2015).

A survey conducted among the participants in the experimental groups one year after completing the study of various disciplines has revealed that at least 80% of knowledge and skills had not been forgotten.

Research has shown that the learners' existing systems thinking knowledge and skills is one of the major factors in intensifying the learning process. Our experiments have managed to reduce by 60-70% the time allocated for the study of independent disciplines.

The following factors contributed to the development of the learners' creativity:

Systems study of an entity (learning material) under different functioning and development conditions;

Acquisition and implementation of the proposed systems methods for examining the entities under discussion along with various types of activity and actions aimed at meeting the challenges and accomplishing various tasks at "standard", creativity and research levels (featuring, at least, three difficulty levels);

Development of systems thinking skills and that of the systems approach to cognitive, theoretical and practical activity;

Improvement of the learners' self-management skills.

Conclusions

1. We have developed, in the learning context, the approach consisting in a flexible combination of traditional and supplementary/developmental teaching based on the systems approach with the use of specially worked out methods and techniques.

2. The systems approach simple mention on the basis of a standard text book that is considered to be an open information system.

3. We have developed and successfully implemented into the learning process the totality of methods necessary for shaping systems thinking representations and skills and the systems approach to cognitive, theoretical and practical activities of learners and professionals.

4. Conditions are being created, in the process of shaping systems thinking skills, for acquiring the recommended types of activity facilitating the integrated discovery of real life.

5. After many years of implementing in to teaching the teaching methods based on the systems approach, experiments have established and confirmed a persistent and efficient impact of shaping the learners' systems thinking skills on the development of their intellectual capabilities.

6. The researchers have revealed the dependence of the increase in the learners' growth of efficiency and quality of "subject matter" thinking on the extent to which they had acquired systems thinking skills.

7. The existence of certain systems representations along with systems thinking skills is a factor in intensifying the learning process and increasing the efficiency of the learners' independent work.

8. The process of implementing learning practices based on the systems approach has revealed the mechanism of developing the learners' creativity, the main components of which are:

The proposed systems approach methods as well as a variety of activities that are to be understood and actively implemented;



Problem, assignment and exercise books featuring three difficulty levels;

Implementation of the acquired knowledge: 1) at the “standard” level (solving problems and performing tasks that meet the education standard); 2) at the creativity level (solving problems and performing tasks that demand a creative approach); 3) at the research level (carrying out learning and scientific research that relate to the entity under study, to various problems and challenges).

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